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Naval Surface Warfare Center
Indian Head, MD 20640-5035

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PROPOSED QUANTITY-DISTANCE RULES FOR HAZARD DIVISION 1.2 AMMUNITION

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An extensive hazard division (HD) 1.2 open-air testing program has now been completed. A test program investigating in-structure HD 1.2 effects is currently underway. The results of these programs and a literature survey form the basis of a database of HD 1.2 effects. Currently, for quantity-distance purposes, HD 1.2 ammunition is treated differently than HD 1.1 items. The database of HD 1.2 effects suggests that this difference is not appropriate. Based on this database, proposed changes to the quantity-distance criteria for HD 1.2 ammunition have been developed. This paper will describe those proposed changes. It will then compare the proposed changes with both the current United States and NATO/United Kingdom criteria.

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FOREWORD

This work was sponsored by the United States Department of Defense Explosives Safety Board (DDESB) as part of their ongoing research and development program. The 105-mm cartridge and 81-mm mortar testing were jointly sponsored by the DDESB and the United Kingdom Explosives Storage and Transport Committee. The testing of these items was under the direction of Mr. Carl Halsey at the Naval Air Warfare Center, Weapons Division, China Lake, CA. The debris collection and analysis were under the direction of Mr. W.D. Houchins of the Dahlgren Division, Naval Surface Warfare Center.

A preliminary version of this report was presented at the 27th DOD Explosives Safety Seminar with Swisdak, Houchins, Ward, and Gould as coauthors.

Approved and released by:

K. Wayne Reed

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Director, Explosive Technology Application Division

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CHAPTER 1. INTRODUCTION

Interim or status reports on the United States and United Kingdom sponsored hazard division (HD) 1.2 testing program have been previously presented at both the United States and Australian Safety Seminars.[1-4] In addition, two Naval Surface Warfare Center technical reports have been published that describe the results obtained up to the time of their publication.[5-6] Since these reports, additional testing has been completed both in the United States and in Germany. A revised summary of the U.S./U.K. open-air testing program was described in a paper presented by W.D. Houchins at the 27th DOD Explosives Safety Seminar.[7]

The approach described herein represents the current thinking of the authors. It has evolved over the last several years and is significantly different from earlier versions. This material has not been fully staffed and does not represent an official position.

1.1 U.S./U.K. Open Air Testing

The testing portion of the U.S./U.K.-sponsored HD 1.2 open-air testing program has been concluded. During this effort, fourteen tests were completed and analyzed. This portion of the program has used three separate rounds. These are the 105-mm, TNT-loaded cartridge, 105-mm, Composition B-loaded cartridge, and 81-mm, Composition B-loaded mortar round. Other work in the United States, Norway, and France has used various types of 40-mm cartridges. Further details of these tests are provided in Table I.

Table I. United States/United Kingdom Open Air Testing Program

Test identifier	No. of pallets	Boxes per pallet	No. of rounds	Test date	Test item	Type of box	Type of test
1	1	15	30	7-May-91	105-mm/TNT	Wood	External fire
2	1	15	30	24-Jun-91	105-mm/TNT	Wood	External fire
3	1	15	30	29-Jul-91	105-mm/TNT	Wood	External fire
4	8	15	240	29-Oct-91	105-mm/TNT	Wood	External fire
5	8	15	240	29-Apr-92	105-mm/TNT	Wood	External fire
6	27	16	864	28-Oct-92	105-mm/TNT	Wood	External fire
7	3	16	96	3-May-94	105-mm/Comp. B[a]	Wood	External fire
8	2	30	180	15-Sep-94	81-mm/Comp. B	Wood	External fire
8A	—	—	12	8-Sep-94	81-mm/Comp. B	Metal	External fire[b]
9	2	30	180	11-May-94	81-mm/Comp. B	Metal	External fire
10	4	16	128	17-May-94	105-mm/Comp. B	Wood	External fire
11A	—	—	15	20-Sep-95	81-mm/Comp. B	Metal	Stack[b]
11B	—	—	15	20-Sep-95	81-mm/Comp. B	Metal	External fire[b]
12	8	30	720	26-Sep-95	81-mm/Comp. B	Metal	External fire

[a]Tested without nose plugs.
[b]Pseudo-hazard classification tests.

The M1 105-mm cartridge is a semi-fixed, high explosive artillery round. The projectile body is fabricated from forged steel and weighs approximately 11.7 kg (25.8 lb). An aluminum (or plastic) shipping plug is assembled into the nose of each projectile instead of a fuze. (In all of the open-air tests, rounds with aluminum nose plugs were used unless otherwise noted.) The propelling charge consists of approximately 1.4 kg (3 lb) of M1 propellant contained in a spiral-wrap steel case. Each propelling charge case weighs approximately 2.1 kg (4.7 lb). Several variants of the M1 cartridge have been produced with projectiles that contain either TNT or Composition B explosive. Each round contains approximately 2.2 kg (4.9 lb) of high explosive. The round is packaged two to a wooden box. A pallet consists of either 15 or 16 wooden boxes. This cartridge is currently hazard classified in the United States as (12)1.2E; i.e., its maximum fragment range is 1,200 feet (366 m) based on the original United States hazard classification testing.

The items tested were taken from ammunition with the DODIC/NSN/NALC (Department of Defense information code/national stock number/naval ammunition logistics code) codes shown in Table II.

Table II. Identification of Rounds Tested

TNT	Composition B
M1 105-mm	
C445 1315-00-145-7554	C445 1315-00-028-4857
C445 1315-00-146-6853	C445 1315-00-028-4860
C445 1315-00-215-8884	C445 1315-00-231-4629
—	C445 1315-00-926-4081
M374A2 81-mm	
—	C236 1315-00-935-6007
—	C236 1315-00-935-6013

The M374A2 is an unfuzed, 81-mm mortar cartridge. The complete round consists of a projectile body, a fin assembly that includes a cartridge housing, a propellant charge with two types of increment charges, and an ignition charge. Each round contains 0.95 kg (2.1 lb) of Composition B explosive and 0.15 kg (0.33 lb) of M1 propellant. The item is packaged one per container, three containers per wooden box. A pallet consists of 30 boxes. The round is currently hazard classified in the United States as (08)1.2E; i.e., its maximum fragment range is 800 feet (244 m) based on the original United States hazard classification testing. The items tested were taken from ammunition with the DODIC/NSN/NALC codes shown in Table II.

The 81-mm mortar rounds used on Tests 8 and 10 were in their standard packaging. This consisted of each round contained in a fiberboard tube, with three such tubes inside each wooden box. The wooden boxes were formed into pallets with 30 boxes on each pallet. To investigate the effects of the packaging on the observed HD 1.2 behavior, rounds were repackaged for several tests (Tests 8A, 9, 11A, 11B, and 12). Rounds were removed from their regular packaging. Each round was placed inside a plastic handling tube, replacing the fiberboard tubes. These plastic tubes were then placed in metal boxes (three rounds to a box). On Tests 9 and 12, the metal boxes were stacked into pallet configurations. These pallets had the same approximate dimensions as those containing wooden boxes and held the same numbers of rounds. The test configurations for Tests 8A, 11A, and 11B were similar to those used for hazard classification purposes. These tests were done to ensure that the change in packaging did not result in an apparent change in the hazard classification to HD 1.1.

1.2 Other Data

Beyond the data collected for this program, related information has been obtained from the published literature and from other test reports describing recent work. This information includes Japanese work on 105-mm cartridges[8], and Norwegian[9], U.S.[10], and German[11] work on 40-mm cartridges.

A Japanese paper describes bonfire tests conducted on TNT-loaded, 105-mm projectiles inside a tunnel, simulating underground storage. These results confirmed the type of behavior observed on the U.S./U.K. open-air tests. There was a delay of at least 15 to 20 minutes after the start of the fire before the first event occurred. After that first event, the rounds reacted sequentially "popcorn-fashion."

The Norwegian 40-mm data were obtained as part of an investigation of a shipping accident that occurred in May 1985. The data obtained from this study were used by U.S. investigators to calculate fragment density versus range information for this round. These test data showed that this round had a maximum fragment range of approximately 152 meters (500 ft).

About 15 years ago, as part of the Fragment Hazard Investigation Program, the Department of Defense Explosives Safety Board sponsored a series of bonfire tests of 40-mm antiaircraft rounds. The early tests in this program were conducted at the Dahlgren Division of the Naval Surface Warfare Center. Because of constraints imposed by the test site, fragment/debris recovery could only be accomplished out to a range of 500 feet. Based on these tests, it was felt that fragments/debris were being thrown to ranges greater than 500 feet. Consequently, the final test of the series was moved to White Sands Missile Range, New Mexico. The White Sands event involved 36 pallets (6,912 rounds) of 40-mm ammunition. Because of the large number of rounds involved, the statistics of the recovery process meant that the maximum fragment range should be well defined; i.e., because of the large number of rounds involved, the probability of recovering a fragment near the true maximum range should be relatively high.

Recently, personnel from the Dahlgren Division re-examined these data and concluded that this data set was probably flawed. The exact nature of the rounds tested cannot be decided; i.e., neither the type of round (description and DODIC/NSN/NALC) nor weight of either the explosive or propellant was available. Further, the test site had been previously used for other testing, and the fragment recovery operations were not under the direct supervision of project personnel. Thus, items from previous tests could have been attributed to the 40-mm test results. Because of these questions, the authors have chosen not to give this data set as much credibility as the other data described in this section.

As their contribution to the NATO AC/258 (Group of Experts on the Safety Aspects of Transportation and Storage of Military Ammunition and Explosives) effort to better characterize HD 1.2 hazards and their corresponding quantity-distance criteria, Germany is currently acquiring data on two of their 40-mm rounds. To date, two external fire tests have been conducted with full fragment recovery. Preliminary results from these tests have been made available, and the data have been added to the HD 1.2 database.

The ammunition used by the Japanese was a 105-mm cartridge that was similar in design to that used in the U.S. and U.K. testing. The explosive fill was TNT, and the explosive weight was about 2.2 kg (4.85 lb). The cartridge contained approximately 1.2 kg (2.65 lb) of an unknown type of propellant. The cartridges were packaged in wooden boxes. The 40-mm cartridge tested by the Germans contains 0.12 kg (0.26 lb) of 75/25 HMX/TNT. It also contains 0.47 kg (1.04 lb) of BD 5010 propellant. The German round is packaged in metal boxes. In contrast, the Norwegian Mk 2, 40-mm HE-T cartridges contained 0.064 kg (0.14 lb) of pressed TNT. The Norwegians examined both wooden and metal packaging. The information on these rounds is summarized in Table III. All of the additional testing is summarized in Table IV.

Table III. Description of Ammunition Used in Other HD 1.2 Tests

Country	Item	Stock No.	Explosive		Propellant		Net explosive quantity (kg)
			Type	Weight (kg)	Type	Weight (kg)	
Germany	Cart., 40-mm x 365 DM 31	NSN 1310-12-127-3749	HMX/TNT (75/25)	0.120	BD 5010	0.470	0.597
Norway	Mk 2 40-mm HE-T cart.	Unknown	Pressed TNT	0.064	Unknown	Unknown	0.064
Japan	105-mm H-shell (cart.)	Unknown	TNT	2.2	Unknown	1.2	Unknown

Table IV. Additional Open-Air Testing

Country	No. of rounds	Test date	Test item	Type of box	Type of test
United States	6912	Jul-80	40-mm cartridge	Metal	Bonfire
Norway	80	1985-1986	40-mm cartridge	Metal	Bonfire
Norway	30	1985-1986	40-mm cartridge	Wood	Bonfire
Germany	240	Sep-95	40-mm cartridge	Metal	Bonfire
Germany	240	Jan-96	40-mm cartridge	Metal	Bonfire

1.3 In-Structure Testing

Over the last several years, the U.K. and Australia have conducted several bonfire tests inside a SPANTECH igloo. Each test used one or more pallets of 105-mm cartridges. The test items were supplied from U.S. inventories and had one of the identification codes shown in Table II.

In June 1996, the United States conducted a bonfire test inside a recently designed miniature magazine. This test also used 105-mm cartridges with the identification codes shown in Table II.

In late August 1996, an accident involving HD 1.2 ammunition occurred inside an earth-covered magazine at Red River Army Depot, Texarkana, Texas. The magazine contained large quantities of both gun propellant and TNT-loaded, M1 105-mm cartridges. The gun propellant was accidentally ignited, and the resulting fire burned for several days.

Both the SPANTECH and miniature magazine tests produced results that mirrored the behavior observed on the U.S./U.K. open-air tests. There was a delay of at least 15 to 20 minutes after the start of the fire before the first event occurred. After that first event, the rounds generally reacted sequentially "popcorn-fashion." The materials involved in the Red River accident behaved in a more benign manner, with fewer explosive-type reactions. Details of these in-structure test results, including a discussion of the Red River accident, will be reported separately.[12]

The U.K. has recently conducted a series of HD 1.2 tests inside brick structures beginning in late January 1997. As these data become available, they will be included in the HD 1.2 in-structure database. All of the HD 1.2 in-structure testing conducted thus far is summarized in Table V.

Table V. In-Structure Testing

Country	No. of rounds	Test date	Test tem	Type of box	Type of structure	Type of test
Japan	24	Dec-82	105-mm/TNT	Wood	Tunnel	Bonfire
U.K./Australia	32	14-Nov-96	M1 105-mm/Comp B	Wood	SPANTECH	Bonfire
U.K./Australia	32	16-Nov-96	M1 105-mm/TNT	Wood	SPANTECH	Bonfire
U.K./Australia	32	19-Nov-94	M1 105-mm/Comp B	Wood	SPANTECH	Bonfire
U.K./Australia	256	24-Nov-94	M1 105-mm/Comp B	Wood	SPANTECH	Bonfire
U.S.	120	24-Jun-96	M1 105-mm/Comp B	Wood	Miniature magazine	Bonfire
U.S.	5681	21-Aug-96	M1 105-mm/TNT	Wood	Earth-covered magazine	Accident--fire
U.K./Australia	4800	13-Sept-96	M1 105-mm/Comp B	Wood	SPANTECH	Bonfire
U.K.	32	22-Jan-97	M1 105-mm/TNT	Wood	Double-walled brick	Bonfire
U.K.	128	25-Jan-97	M1 105-mm/TNT	Wood	Double-walled brick	Bonfire
U.K.	128	29-Jan-97	M1 105-mm/TNT	Wood	Double-walled brick	Bonfire

The results of these test programs have been used to revise the description of the accepted behavior of HD 1.2 items. These results also form the basis for proposed changes to the appropriate explosives safety standards. The subsequent sections of this report will discuss these topics in more detail.

CHAPTER 2. CURRENT RULES

The current NATO and United Kingdom quantity-distance prescriptions are defined in the Allied Ammunition Storage and Transport Publication, AASTP-1, for NATO[13] and Explosives Storage and Transport Committee (ESTC) Leaflet 5 Part 2 for the U.K.[14] Under this system, there is a broad division, based loosely on caliber, into–

(a) Those items which give small fragments of moderate range (caliber < 60 mm): IBD = $53Q^{0.18}$ (IBD is inhabited building distance in meters, Q is net explosive quantity in kilograms) with a minimum of 180 meters (591 ft) and a maximum of 410 meters (1,345 ft).

(b) Those items which give large fragments with considerable range (caliber > 60 mm): IBD = $62Q^{0.18}$ with a minimum of 270 meters (886 ft) and a maximum of 560 meters (1,837 ft).

Note that the 60-mm division is considered somewhat arbitrary; however, it is purported to be based on actual test data. These data are not currently available, and the authors have not been able to locate their sources.

United States quantity-distance regulations are defined in the Department of Defense Ammunition and Explosives Safety Standards.[15] Currently, for HD 1.2 items, safety distances are related to the maximum range of hazardous projections as determined by hazard classification tests performed for that specific ammunition item.

The NATO and U.K. criteria differ in principle from the current U.S. criteria. The U.S. criteria are round-specific and quantity-independent, whereas the NATO/U.K. criteria are round-generic and quantity-dependent.

There is one other major difference between the U.S. and the NATO/U.K. approaches. That involves the calculation of the net explosive quantity (NEQ) expressed in kilograms or the net explosive weight (NEW) expressed in pounds. In the U.S., the weight of any HD 1.3 material is normally considered part of the total NEW. Under the NATO/U.K. approach, only those energetic materials shown to contribute to the explosion effects need to be considered, although, in practice, the weight of the HD 1.3 material is included when no reliable data exists to do otherwise.

CHAPTER 3. PROPOSED HD 1.2 QUANTITY-DISTANCE RULES FOR THE UNITED STATES AND NATO

3.1 Approach

Based on the data that have been obtained and/or analyzed during this program, an approach similar to that taken currently by NATO and the U.K. seems appropriate—namely, a quantity-distance (QD) range that is dependent upon a combination of (1) the net explosive weight of a single round and (2) the total HD 1.1 weight of all the items in the stack. This would eliminate the U.S. requirement for a fragment recovery test for every new weapon system.

The information obtained thus far in the program suggests that, for the purposes of QD determination (i.e., generation of overpressure and hazardous debris throw), it should be assumed that any HD 1.3 material that is present does not contribute to the total event unless there is evidence otherwise. The NEW or NEQ for a single round will, therefore, be defined as the weight of the HD 1.1 material plus the weight of any HD 1.3 material known or demonstrated to contribute to the event. In some situations, there may only be HD 1.3 materials and no HD 1.1 material present. Examples of these situations might include certain rocket motors or kinetic energy penetration rounds. In these unique situations, the HD 1.3 weight should be used as the basis for HD 1.2 QD calculations.

The following definitions are required before we can continue. The net explosive weight (NEW) of an item is the sum of the weight of the HD 1.1 and 1.3 material contained in an item. The NEW for QD (NEW/QD) for an item includes a 100% contribution of the HD 1.1 material and any known or documented contribution of the HD 1.3 materials. The quantity-distance weight (QDW) is equal to the number of items multiplied by the NEW/QD for a single item. The maximum credible event (MCE) is the total weight of the HD 1.1 and 1.3 materials, known to contribute to an event, that would be involved in the worst, single event that is likely to occur. The inhabited building distance (IBD) is that range at which the air blast overpressure falls to a value of either 1.2 psi (8.3 kPa) in the U.S. or 0.725 psi (5.0 kPa) in NATO/U.K. and the density of hazardous debris falls to a value of one hazardous fragment per 600 ft^2 (55.7 m^2) (Note: A hazardous fragment is defined as one having an impact energy of 58 ft-lb [79 J] or greater.). For HD 1.2 items, the IBD range is controlled by debris rather than air blast.

3.2 Proposed Rules

The effects produced by the functioning of HD 1.2 items will vary with the size and weight of the item. It is proposed that all HD 1.2 ammunition be separated into two categories to account for the differences in magnitude of these effects for setting QD criteria for storage. The least hazardous items, called Category 1 items, have an NEW/QD less than or equal to 0.30 pound (0.136 kg). The more hazardous items are called Category 2 items and have an NEW/QD greater than 0.30 pound (0.136 kg). These two categories are shown below with their definitions:

Category 1: NEW/QD $\leq$ 0.30 lb (0.136 kg)
Category 2: NEW/QD > 0.30 lb (0.136 kg)

The breakpoint between the two categories is based on all of the test data that are currently available. Category 1 primarily uses a combination of the Norwegian and German 40-mm data. Category 2 is based on a combination of the 81-mm mortar and 105-mm cartridge data. Within each category, a curve fit of the type

$$IBD = A + B \times [\ln (QDW)] + C \times [\ln (QDW)]^2 \quad (1)$$

was made to the maxima of the data with maximum and minimum ranges also being defined.

For Category 1, the Norwegian data were dominant for low values of QDW, while the German data controlled the fit at large values of QDW. For Category 2, the 81-mm data controlled the results except at large values of QDW. The following assumptions were made in all of the analyses that were performed.

(1) The QDW was composed of only the HD 1.1 material weight.
(2) Only 50% of the total number of rounds present reacted.
(3) Debris densities were computed using a modified pseudo-trajectory normal assumption.[16]

A more detailed description of this process will be given in Reference 17.

The results of these curve fits are shown below and are given in the notes at the bottoms of Tables VI and VII for Category I and VIII and IX for Category 2.

Presently, in both the U.S. tables and the U.K./NATO safety standards there are no accepted definitions for the debris density at either public traffic route (PTR) distance or intraline distance (ILD). PTR distance is computed as 60% of the IBD for the U.S. and two-thirds of the IBD for U.K./NATO. ILD allows for the progressive nature of explosions involving endangered areas before the progression involves large numbers of items. Exposed structures may be extensively damaged by projections, and delayed propagation of explosions may occur due to the ignition of combustibles by projections. ILD is computed as 50% of the IBD in the U.S.. These relationships between PTR/ILD distances and IBD were originally based on air blast phenomena for HD 1.1 materials without consideration of debris. However, they currently represent the best available definitions for both distances.

Category 1:

$$IBD = 22.8 + 18.8 \times [\ln(QDW)] - 0.65 \times [\ln(QDW)]^2 \quad (2)$$

with QDW in kilograms and IBD in meters with a 100-meter minimum distance and a 158-meter maximum distance. If the QDW of Category 1 HD 1.2 items at an operating line potential explosion site (PES) is limited to 2,268 kg, then the ILD may be reduced to 61 meters.

The equation in English units corresponding to equation (2) is:

$$IBD = 24.7 + 65.0 \times [\ln(QDW)] - 2.12 \times [\ln(QDW)]^2 \quad (3)$$

with QDW in pounds and IBD in feet with a 328-foot minimum distance and a 520-foot maximum distance. If the QDW of Category 1 HD 1.2 items at an operating line PES is limited to 5,000 pounds, then the ILD may be reduced to 200 feet.

Category 2:

$$IBD = -60.9 + 51.9 \times [\ln(QDW)] - 0.18 \times [\ln(QDW)]^2 \quad (4)$$

with QDW in kilograms and IBD in meters with a 200-meter minimum distance and a 607.0-meter maximum distance.

The equation in English units corresponding to equation (4) is:

$$IBD = -334.0 + 169.2 \times [\ln(QDW)] + 0.59 \times [\ln(QDW)]^2 \quad (5)$$

with QDW in pounds and IBD in feet with a 656-foot minimum distance and a 2,000-foot maximum distance..

If the NEW of the ammunition item is greater than 100 pounds (45.4 kg), then a minimum IBD of 1,250 feet (380.9 m) must be applied. This increased minimum distance is based on the assumption that for items with an NEW greater than 100 pounds (45.4 kg), there is a reasonable likelihood that the storage structure will fail. If such a failure were to occur, the secondary structural debris must be considered.

The form of Equation (1) was selected for a specific reason. All debris/fragments produced by the detonation or deflagration of a weapon will have some maximum range. The IBD will asymptotically approach this range as the QDW is increased. A function with the form of Equation (1) is the simplest that begins to mirror this behavior. If an equation of the form

$$D = Aq^n \quad (6)$$

were used as in the U.K./NATO approach, this asymptotic behavior would not be realized.

Tables VI through IX show the proposed IBDs, PTRs, and ILDs for both categories of HD 1.2 ammunition in SI and English units.

Intermagazine distance (IMD) is dependent upon the types of structures acting as both the PES and the exposed site (ES). Tables X and XI provide the appropriate IMD separations in both SI and English units for various combinations of ES and PES. The primary source for the distances given in the tables is Table 2, Annex I-A, of Reference 13.

When storing mixed Categories of HD 1.2 ammunition, the following rule shall apply: Use the total QDW and apply the distances for the higher category. This procedure is shown below:

Categories Involved	Distances to Be Applied
1	Apply Category 1 distances
2	Apply Category 2 distances
1+2	Apply Category 2 distances

Table VI. Proposed HD 1.2 Quantity-Distances for Category 1 Munitions in SI Units

[New/QD ≤ 0.136 kg]

QDW (kg)	IBD[a,b] (m)	U.S. PTR[c] (m)	U.K./NATO PTR[d] (m)	ILD[e] (m)	QDW (kg)	IBD[a,b] (m)	U.S. PTR[c] (m)	U.K./NATO PTR[d] (m)	ILD[e] (m)
0.2	100	60	66.7	50	4,000	134.0	80.4	89.3	67.0
0.5	100	60	66.7	50	5,000	135.8	81.5	90.5	67.9
1	100	60	66.7	50	6,000	137.2	82.3	91.4	68.6
2	100	60	66.7	50	7,000	138.3	83.0	92.2	69.1
5	100	60	66.7	50	8,000	139.3	83.6	92.8	69.6
10	100	60	66.7	50	9,000	140.1	84.1	93.4	70.0
20	100	60	66.7	50	10,000	140.8	84.5	93.9	70.4
40	100	60	66.7	50	15,000	143.5	86.1	95.7	71.7
60	100	60	66.7	50	20,000	145.2	87.1	96.8	72.6
80	100	60	66.7	50	25,000	146.5	87.9	97.7	73.3
100	100	60	66.7	50	30,000	147.5	88.5	98.4	73.8
150	100.7	60.4	67.1	50	40,000	149.0	89.4	99.4	74.5
200	104.2	62.5	69.4	52	50,000	150.1	90.1	100.1	75.1
300	108.9	65.3	72.6	54	60,000	151.0	90.6	100.6	75.5
400	112.1	67.3	74.7	56	70,000	151.6	91.0	101.1	75.8
500	114.5	68.7	76.4	57.5	80,000	152.2	91.3	101.5	76.1
600	116.5	69.9	77.6	58.0	90,000	152.7	91.6	101.8	76.3
700	118.1	70.8	78.7	59	100,000	153.1	91.9	102.1	76.5
800	119.4	71.7	79.6	59.5	125,000	153.9	92.3	102.6	77.0
900	120.6	72.4	80.4	60.5	150,000	154.5	92.7	103.0	77.3
1,000	121.6	73.0	81.1	61	175,000	155.0	93.0	103.4	77.5
1,500	125.5	75.3	83.7	61[f]	200,000	155.4	93.3	103.6	77.7
2,000	128.1	76.9	85.4	61[f]	225,000	155.8	93.5	103.8	77.9
3,000	131.7	79.0	87.8	65.8	>226,795	158.0	94.8	105.3	79.0

[a]IBD = 22.8 + 18.8 × [ln(QDW)]-0.65 × [ln(QDW)]^2, QDW in kilograms, IBD in meters with a 100-m minimum distance.
[b]Use of equation to determine IBD ranges for other weights is allowed.
[c]U.S. PTR = 60% of IBD.
[d]U.K./NATO PTR = two-thirds of IBD.
[e]ILD = 50% of IBD.
[f]If the QDW of Category 1 HD 1.2 items at an operating line PES is limited to 2,268 kg, then ILD may be reduced to 61 m.

Table VII. Proposed HD 1.2 Quantity-Distances for Category 1 Munitions in English Units

[New/QD ≤ 0.30 lb]

QDW (lb)	IBD[a,b] (ft)	U.S. PTR[c] (ft)	U.K./NATO PTR[d] (ft)	ILD[e] (ft)	QDW (lb)	IBD[a,b] (ft)	U.S. PTR[c] (ft)	U.K./NATO PTR[d] (ft)	ILD[e] (ft)
1	328	197	219	164	7,000	434	260	289	217
2	328	197	219	164	8,000	438	263	292	219
5	328	197	219	164	9,000	441	264	294	220
10	328	197	219	164	10,000	444	266	296	222
20	328	197	219	164	15,000	454	272	302	227
40	328	197	219	164	20,000	460	276	307	230
60	328	197	219	164	25,000	466	279	310	233
80	328	197	219	164	30,000	469	282	313	235
100	328	197	219	164	40,000	475	285	317	238
150	328	197	219	164	50,000	480	288	320	240
200	328	197	219	164	60,000	483	290	322	242
300	328	197	219	164	70,000	486	292	324	243
400	338	203	225	169	80,000	488	293	326	244
600	354	212	236	177	90,000	490	294	327	245
800	364	219	243	182	100,000	492	295	328	246
1,000	373	224	248	186	150,000	498	299	332	249
1,500	387	232	258	194	200,000	502	301	335	251
2,000	396	238	264	198	250,000	505	303	337	253
2,500	403	242	269	202 (200)[f]	300,000	507	304	338	254
3,000	409	246	273	205 (200)[f]	350,000	509	305	339	254
3,500	414	248	276	207 (200)[f]	400,000	510	306	340	255
4,000	418	251	279	209 (200)[f]	450,000	512	307	341	256
5,000	425	255	283	213 (200)[f]	500,000	513	308	342	256
6,000	430	258	286	215	>500,000	520	312	347	260

[a]IBD = 24.7 + 65.0 × [ln(QDW)]-2.12 × [ln(QDW)]^2, QDW in pounds, IBD in feet with a 328-ft minimum distance.
[b]Use of equation to determine IBD ranges for other weights is allowed.
[c]U.S. PTR = 60% of IBD.
[d]U.K./NATO PTR = two-thirds of IBD.
[e]ILD = 50% of IBD.
[f]If the QDW of Category 1 HD 1.2 items at an operating line PES is limited to 5,000 lb, then ILD may be reduced to 200 ft.

Table VIII. Proposed HD 1.2 Quantity-Distances for Category 2 Munitions in SI Units

[New/QD > 0.136 kg]

QDW (kg)	IBD[a,b] (m)	U.S. PTR[c] (m)	U.K./NATO PTR[d] (m)	ILD[e] (m)	QDW (kg)	IBD[a,b] (m)	U.S. PTR[c] (m)	U.K./NATO PTR[d] (m)	ILD[e] (m)
0.2	200	120.0	133.3	100.0	5,000	394.2	236.5	262.8	197.1
0.5	200	120.0	133.3	100.0	6,000	404.2	242.5	269.5	202.1
1	200	120.0	133.3	100.0	7,000	412.7	247.6	275.1	206.4
2	200	120.0	133.3	100.0	8,000	420.1	252.0	280.0	210.0
5	200	120.0	133.3	100.0	9,000	426.6	255.9	284.4	213.3
7	200	120.0	133.3	100.0	10,000	432.4	259.4	288.3	216.2
10	200	120.0	133.3	100.0	15,000	454.8	272.9	303.2	227.4
20	200	120.0	133.3	100.0	20,000	470.7	282.4	313.8	235.4
30	200	120.0	133.3	100.0	25,000	483.1	289.9	322.1	241.6
50	380.9 or 200[f]	228.6 or 120[f]	253.9 or 133.3[f]	190.5 or 100[f]	30,000	493.3	296.0	328.8	246.6
70	380.9 or 200[f]	228.6 or 120[f]	253.9 or 133.3[f]	190.5 or 100[f]	40,000	509.3	305.6	339.5	254.6
100	380.9 or 200[f]	228.6 or 120[f]	253.9 or 133.3[f]	190.5 or 100[f]	50,000	521.7	313.0	347.8	260.9
200	380.9 or 219.1[f]	228.6 or 131.5[f]	253.9 or 146.1[f]	190.5 or 109.6[f]	60,000	531.9	319.1	354.6	265.9
300	380.9 or 241.0[f]	228.6 or 144.6[f]	253.9 or 160.7[f]	190.5 or 120.5[f]	70,000	540.5	324.3	360.3	270.3
500	380.9 or 268.6[f]	228.6 or 161.2[f]	253.9 or 179.1[f]	190.5 or 134.3[f]	80,000	548.0	328.8	365.3	274.0
700	380.9 or 286.8[f]	228.6 or 172.1[f]	253.9 or 191.2[f]	190.5 or 143.4[f]	90,000	554.6	332.7	369.7	277.3
800	380.9 or 294.1[f]	228.6 or 176.4[f]	253.9 or 196.0[f]	190.5 or 147.0[f]	100,000	560.5	336.3	373.7	280.2
900	380.9 or 300.5[f]	228.6 or 180.3[f]	253.9 or 200.3[f]	190.5 or 150.2[f]	120,000	570.7	342.4	380.5	285.4
1,000	380.9 or 306.2[f]	228.6 or 183.7[f]	253.9 or 204.1[f]	190.5 or 153.1[f]	140,000	579.4	347.6	386.2	289.7
1,500	380.9 or 328.3[f]	228.6 or 197.0[f]	253.9 or 218.9[f]	190.5 or 164.1[f]	160,000	586.9	352.1	391.2	293.4
2,000	380.9 or 344.0[f]	228.6 or 206.4[f]	253.9 or 229.3[f]	190.5 or 172.0[f]	180,000	593.5	356.1	395.7	296.7
2,500	380.9 or 356.2[f]	228.6 or 213.7[f]	253.9 or 237.5[f]	190.5 or 178.1[f]	200,000	599.4	359.6	399.6	299.7
3,000	380.9 or 366.2[f]	228.6 or 219.7[f]	253.9 or 244.1[f]	190.5 or 183.1[f]	220,000	604.8	362.9	403.2	302.4
4,000	381.9	229.2	254.6	191.0	>220,000	607.0	364.2	404.7	303.5

[a]IBD = -60.08 + 51.9 × [ln(QDW)] + 0.18 × [ln(QDW)]^2, QDW in kilograms, IBD in meters with a 200-m minimum distance.
[b]Use of equation to determine IBD ranges for other weights is allowed.
[c]U.S. PTR = 60% of IBD.
[d]U.K./NATO PTR = two-thirds of IBD.
[e]ILD = 50% of IBD.
[f]If the MCE for an item is known to be less than 45.4 kg, then the IBD equation given in note a may be used and notes c, d, and e apply for PTR and ILD respectively.

Table IX. Proposed HD 1.2 Quantity-Distances for Category 2 Munitions in English Units

[New/QD > 0.30 lb]

QDW (lb)	IBD[a,b] (ft)	U.S. PTR[c] (ft)	U.K./NATO PTR[d] (ft)	ILD[e] (ft)	QDW (lb)	IBD[a,b] (ft)	U.S. PTR[c] (ft)	U.K./NATO PTR[d] (ft)	ILD[e] (ft)
1	656	394	437	328	7,000	1250 or 1210[f]	750 or 726[f]	833 or 807[f]	625 or 605[f]
2	656	394	437	328	8,000	1250 or 1234[f]	750 or 741[f]	833 or 823[f]	625 or 617[f]
5	656	394	437	328	9,000	1255	753	837	628
10	656	394	437	328	10,000	1274	765	850	637
20	656	394	437	328	15,000	1348	809	898	674
40	656	394	437	328	20,000	1400	840	933	700
60	656	394	437	328	25,000	1440	864	960	720
80	656	394	437	328	30,000	1473	884	982	736
100	1250 or 656[f]	750 or 394[f]	833 or 437[f]	625 or 394[f]	40,000	1525	915	1017	763
150	1250 or 656[f]	750 or 394[f]	833 or 437[f]	625 or 328[f]	50,000	1566	939	1044	783
200	1250 or 656[f]	750 or 394[f]	833 or 437[f]	625 or 328[f]	60,000	1599	959	1066	799
300	1250 or 656[f]	750 or 394[f]	833 or 437[f]	625 or 328[f]	70,000	1627	976	1085	814
400	1250 or 701[f]	750 or 421[f]	833 or 467[f]	625 or 350[f]	80,000	1651	991	1101	826
600	1250 or 773[f]	750 or 464[f]	833 or 515[f]	625 or 386[f]	90,000	1673	1004	1115	836
800	1250 or 823[f]	750 or 494[f]	833 or 549[f]	625 or 412[f]	100,000	1692	1015	1128	846
1,000	1250 or 863[f]	750 or 518[f]	833 or 575[f]	625 or 431[f]	150,000	1766	1060	1178	883
1,500	1250 or 935[f]	750 or 561[f]	833 or 623[f]	625 or 467[f]	200,000	1819	1092	1213	910
2,000	1250 or 986[f]	750 or 592[f]	833 or 657[f]	625 or 493[f]	250,000	1860	1116	1240	930
2,500	1250 or 1026[f]	750 or 616[f]	833 or 684[f]	625 or 513[f]	300,000	1894	1136	1262	947
3,000	1250 or 1058[f]	750 or 635[f]	833 or 706[f]	625 or 529[f]	350,000	1922	1153	1281	961
3,500	1250 or 1086[f]	750 or 652[f]	833 or 724[f]	625 or 543[f]	400,000	1947	1168	1298	973
4,000	1250 or 1110[f]	750 or 666[f]	833 or 740[f]	625 or 555[f]	450,000	1968	1181	1312	984
5,000	1250 or 1150[f]	750 or 690[f]	833 or 767[f]	625 or 575[f]	500,000	1988	1193	1325	994
6,000	1250 or 1183[f]	750 or 710[f]	833 or 788[f]	625 or 591[f]	>500,000	2000	1200	1330	1000

[a]IBD = −334.0 + 169.2 × [ln(QDW)] + 0.59 × [ln(QDW)]^2, QDW in pounds, IBD in feet with a 656-ft minimum distance.
[b]Use of equation to determine IBD ranges for other weights is allowed.
[c]U.S. PTR = 60% of IBD.
[d]U.K./NATO PTR = two-thirds of IBD.
[e]ILD = 50% of IBD.
[f]If the MCE for an item is known to be less than 100 lb, then the IBD equation given in note a may be used and notes c, d, and e apply for PTR and ILD respectively.

Table X. Proposed HD 1.2 Intermagazine Distances in SI Units

[All distances shown are in meters]

To exposed site (ES)*		From potential explosion site (PES)†				
		ECM			AGM (heavy)	AGM (light)
		S	R	F		
ECM (7 bar)	S	2[a]	2[a]	2[a]	2[a]	2[a]
	R	2[a]	2[a]	2[a]	2[a]	2[a]
	FU	2[a]	2[a]	25[b]	25[b]	25[b]
	FB	2[a]	2[a]	25[b]	25[b]	25[b]
ECM (3 bar)	S	2[a]	2[a]	2[a]	2[a]	2[a]
	R	2[a]	2[a]	2[a]	2[a]	2[a]
	FU	2[a]	2[a]	25[b]	25[b]	25[b]
	FB	2[a]	2[a]	25[b]	25[b]	25[b]
ECM (Undefined)	S	2[a]	2[a]	2[a]	2[a]	2[a]
	R	2[a]	2[a]	2[a]	2[a]	2[a]
	FU	90[a]	90[a]	90[a]	90[a]	90[a]
	FB	2[a]	2[a]	25[b]	10[b]	25[b]
AGM (Heavy)	U	90[a]	90[a]	90[a]	90[a]	90[a]
	B	90[a]	90[a]	90[a]	90[a]	90[a]
AGM (Heavy/Roof)	U	2[a]	2[a]	10[a]	90[a]	10[a]
	B	2[a]	2[a]	10[a]	90[a]	10[a]
AGM (Light)	U	90[a]	90[a]	90[a]	90[a]	90[a]
	B	90[a]	90[a]	90[a]	90[a]	90[a]

*Legend:

S–Side; R–rear; F–front; B–barricade; U–unbarricaded
FU–Front unbarricaded; FB–front barricaded
ECM–Earth-covered magazine (7-bar, 3-bar, undefined refers to the strength of the headwall)
AGM–Aboveground magazine; abovegrade, non earth-covered magazine or storage pad
AGM (Heavy)–Buildings with wall thickness ≥ 7 cm of reinforced concrete (11 cm brick); door is barricaded if it faces PES
AGM (Heavy/roof)–AGM (Heavy) with roof thickness > 2.3 cm reinforced concrete; door is barricaded it if faces PES
AGM (Light)–Light structure, open stack, truck, trailer, or railcar.

†Superscripts on distances represent the levels of protection shown:

a-level — There is virtually complete protection against immediate or subsequent fires and explosions caused by blast, flame, firebrands, projections, and lobbed ammunitions. The stocks are likely to be serviceable.

b-level — There is a high degree of protection against immediate propagation of explosion by blast, flame, and projections. There are occasional fires or subsequent explosions caused by firebrands, projections, and lobbed ammunition. The extent of the loss of stocks at the ES is determined by the effectiveness of the fiirefighting. If you increase b-level protection of 25 meters to 90 meters, a-level protection is obtained. If you increase b-level protection of 10 meters to 25 meters, a-level protection is obtained.

Table XI. Proposed HD 1.2 Intermagazine Distances in English Units

[All distances shown are in feet]

To exposed site (ES)*		From potential explosion site (PES)†				
		ECM			AGM (heavy)	AGM (light)
		S	R	F		
ECM (7 bar)	S	7[a]	7[a]	7[a]	7[a]	7[a]
	R	7[a]	7[a]	7[a]	7[a]	7[a]
	FU	7[a]	7[a]	82[b]	82[b]	82[b]
	FB	7[a]	7[a]	82[b]	82[b]	82[b]
ECM (3 bar)	S	7[a]	7[a]	7[a]	7[a]	7[a]
	R	7[a]	7[a]	7[a]	7[a]	7[a]
	FU	7[a]	7[a]	82[b]	82[b]	82[b]
	FB	7[a]	7[a]	82[b]	82[b]	82[b]
ECM (Undefined)	S	7[a]	7[a]	7[a]	7[a]	7[a]
	R	7[a]	7[a]	7[a]	7[a]	7[a]
	FU	295[a]	295[a]	295[a]	295[a]	295[a]
	FB	7[a]	7[a]	82[b]	33[b]	82[b]
AGM (Heavy)	U	295[a]	295[a]	295[a]	295[a]	295[a]
	B	295[a]	295[a]	295[a]	295[a]	295[a]
AGM (Heavy/Roof)	U	7[a]	7[a]	33[a]	295[a]	33[a]
	B	7[a]	7[a]	33[a]	295[a]	33[a]
AGM (Light)	U	295[a]	295[a]	295[a]	295[a]	295[a]
	B	295[a]	295[a]	295[a]	295[a]	295[a]

*Legend:

S–Side; R–rear; F–front; B–barricade; U–unbarricaded
FU–Front unbarricaded; FB–front barricaded
ECM–Earth-covered magazine (7-bar, 3-bar, undefined refers to the strength of the headwall)
AGM–Aboveground magazine; abovegrade, non earth-covered magazine or storage pad
AGM (Heavy)–Buildings with wall thickness ≥ 17.7 inches of reinforced concrete (27.6 inches brick); door is barricaded if it faces PES
AGM (Heavy/roof)–AGM (Heavy) with roof thickness > 5.9 inches reinforced concrete; door is barricaded it if faces PES
AGM (Light)–Light structure, open stack, truck, trailer, or railcar.

†Superscripts on distances represent the levels of protection shown:

a-level — There is virtually complete protection against immediate or subsequent fires and explosions caused by blast, flame, firebrands, projections, and lobbed ammunitions. The stocks are likely to be serviceable.

b-level — There is a high degree of protection against immediate propagation of explosion by blast, flame, and projections. There are occasional fires or subsequent explosions caused by firebrands, projections, and lobbed ammunition. The extent of the loss of stocks at the ES is determined by the effectiveness of the firefighting. If you increase b-level protection of 82 feet to 295 feet, a-level protection is obtained. If you increase b-level protection of 33 feet to 82 feet, a-level protection is obtained.

CHAPTER 4. ESTIMATED IMPACT OF PROPOSED CHANGES

4.1 Comparison Of Proposed Changes With Previous Rules

Figures 1 through 4 compare the changes proposed in Chapter 3 to the current NATO/U.K. criteria. The IBD for U.S.-proposed Category 1 munitions is less than the NATO/U.K. value for items with caliber less than 60 mm for all explosive weights. For larger items, this is not the case. For many items in U.S.-proposed Category 2, the changes will require greater IBDs than the NATO/U.K. criteria.

4.2 HD 1.2 Population

A search of the U.S. Joint Hazard Classification System (JHCS) database (defined in Reference 18) has revealed that as of June 1996 there were 2,110 items that were hazard classified as HD 1.2. Table XII shows how these HD 1.2 items are distributed with regards to IBD and NEW. This table, therefore, describes the kinds and numbers of items that would be affected by these proposed changes.

4.3 Effects On Selected Ammunition Items

Another way to estimate the impact of the changes is to evaluate their effect on selected ammunition items. These evaluations are given in Tables XIII through XIX. Each table gives a description of the item, the current U.S. and NATO QD requirements, and the new, proposed U.S. requirement. The items presented in these tables were chosen by the authors as representative samples. The chosen items were selected simply to demonstrate the effects of the proposed changes.

As expected, the new criteria present mixed results. In some instances, the new criteria would allow the storage of significantly more items with the same current hazard range. In other cases, significantly fewer items could be stored. This indicates that a transition period or rule should be developed to ease the change from the old rules to the new.

4.4 U.S. Transition Rule

For the U.S. it is proposed that these new rules should apply to all HD 1.2 ammunition items entered into the JHCS after the official adoption of this change. Those items that are currently in the JHCS may continue to use the current rules or the service may request on an item-by-item basis that these new rules be applied.

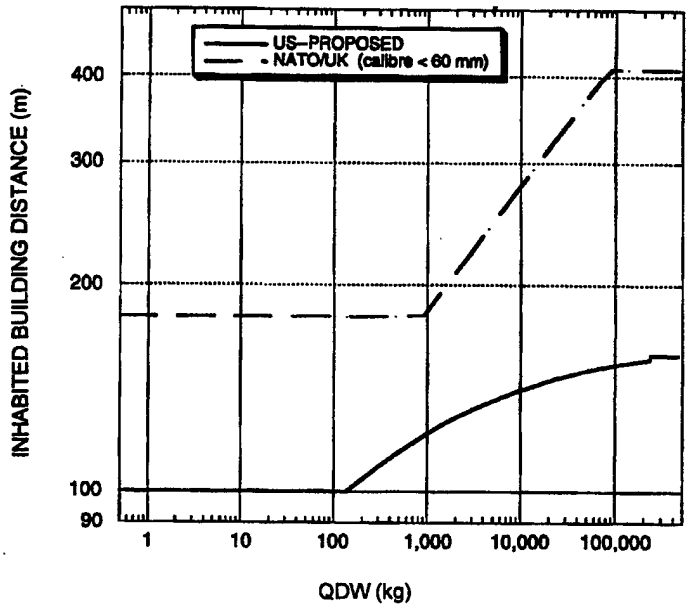

Figure 1. Comparison of Proposed U.S. and Current NATO/U.K. Criteria for Category 1 in SI Units

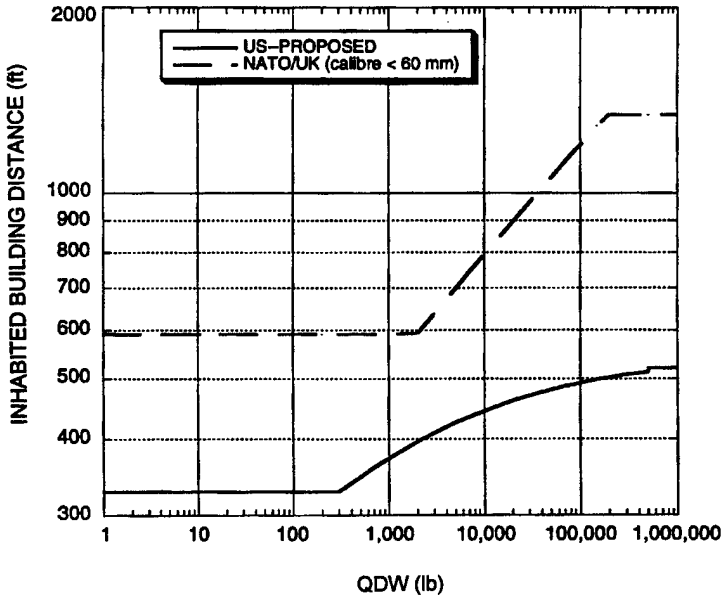

Figure 2. Comparison of Proposed U.S. and Current NATO/U.K. Criteria for Category 1 in English Units

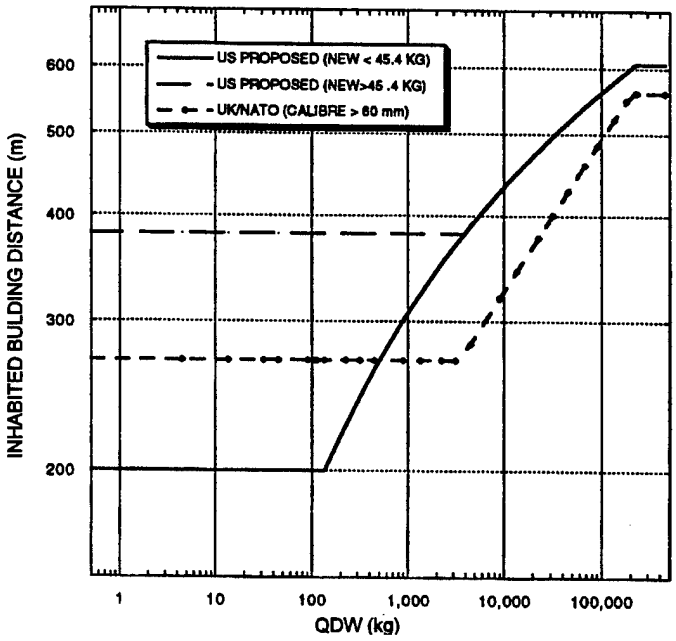

Figure 3. Comparison of Proposed U.S. and Current NATO/U.K. Criteria for Category 2 in SI Units

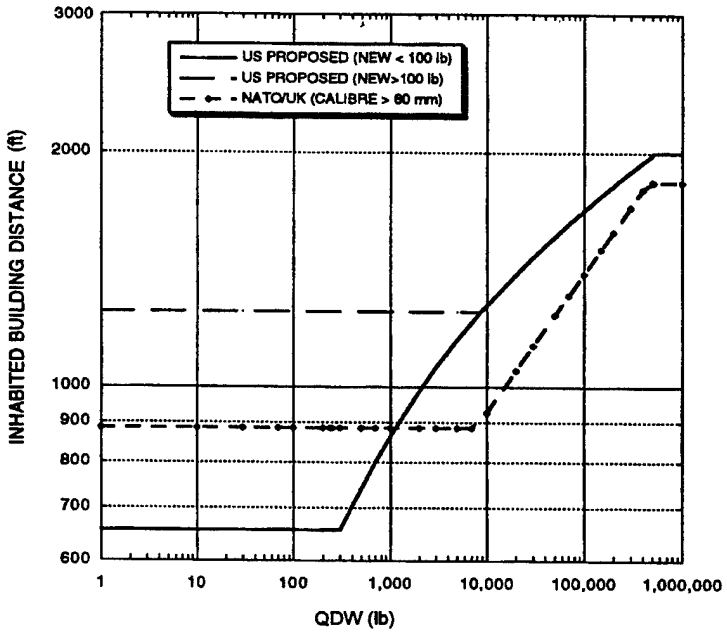

Figure 4. Comparison of Proposed U.S. and Current NATO/U.K. Criteria for Category 2 in English Units

Table XII. Joint Hazard Classification System HD 1.2 IBD Distribution

Inhabited building distance		Weight range		Total
(ft)	(m)	(≤0.30 lb) (≤0.136 kg)	(>0.30 lb) (>0.136 kg)	
200	60.96	4	2	6
300	91.44	1	0	1
400	121.91	508	181	689
500	152.39	6	0	6
600	182.87	1	1	2
700	213.35	0	2	2
800	243.83	121	458	579
900	274.31	0	2	2
1000	304.79	0	2	2
1100	335.26	0	0	0
1200	365.74	87	701	788
1300	396.22	0	3	3
1400	426.70	0	0	0
1500	457.18	0	0	0
1600	487.66	0	0	0
1700	518.13	0	0	0
1800	548.61	0	30	30
Total		728	1382	2110

Table XIII. Impact of Changes on 25-mm Cartridge

[Description: Cartridge, 25-mm, APFSDS-T, M919, M261 container, DODIC A986, Proposed NEW/QD = 0.2324 lb, U.S. IBD = 400 ft, HD 1.1 = 0 lb, HD 1.3 = 0.2324 lb]

No. of terms	QDW		Current U.S. IBD		Current NATO IBD		Proposed U.S. IBD	
	(lb)	(kg)	(ft)	(m)	(ft)	(m)	(ft)	(m)
1	0.2324	0.105	400	121.9	591	180	328	100
5	1.162	0.527	400	121.9	591	180	328	100
10	2.324	1.054	400	121.9	591	180	328	100
20	4.648	2.108	400	121.9	591	180	328	100
50	11.62	5.27	400	121.9	591	180	328	100
100	23.24	10.54	400	121.9	591	180	328	100
200	46.48	21.08	400	121.9	591	180	328	100
500	116.2	52.7	400	121.9	591	180	328	100
1,000	232.4	105.4	400	121.9	591	180	328	100
1,500	348.6	158.1	400	121.9	591	180	332.6	101.4
2,000	464.8	210.8	400	121.9	591	180	343.9	104.8
5,000	1,162	527	400	121.9	591	180	377.9	115.2
10,000	2,324	1,054	400	121.9	597.2	182.0	401.2	122.3
20,000	4,648	2,108	400	121.9	676.6	206.2	422.4	128.7
50,000	11,620	5,271	400	121.9	797.9	243.2	447.4	136.4
100,000	23,240	10,541	400	121.9	903.9	275.5	463.9	141.4
200,000	46,480	21,083	400	121.9	1,024.0	312.1	478.4	145.8

Table XIV. Impact of Changes on 40-mm Cartridge

[Description: Cartridge, 40-mm, HEI-P-NP, DODIC B556, Proposed NEW/QD = 0.2020 lb, U.S. IBD = 800 ft, HD 1.1 weight = 0.2020 lb. HD 1.3 weight = 0.007 lb]

No. of terms	QDW		Current U.S. IBD		Current NATO IBD		Proposed U.S. IBD	
	(lb)	(kg)	(ft)	(m)	(ft)	(m)	(ft)	(m)
1	0.202	0.092	800	243.8	591	180	328	100
5	1.01	0.458	800	243.8	591	180	328	100
10	2.02	0.916	800	243.8	591	180	328	100
20	4.04	1.8	800	243.8	591	180	328	100
50	10.1	4.6	800	243.8	591	180	328	100
100	20.2	9.2	800	243.8	591	180	328	100
200	40.4	18.3	800	243.8	591	180	328	100
500	101	45.8	800	243.8	591	180	328	100
1,000	202	91.6	800	243.8	591	180	328	100
2,000	404	183	800	243.8	591	180	338.4	103.2
5,000	1,010	458	800	243.8	591	180	372.9	113.7
10,000	2,020	916	800	243.8	591	180	396.6	120.9
20,000	4,040	1,833	800	243.8	659.7	201.1	418.3	127.5
50,000	10,100	4,581	800	243.8	778.0	237.1	443.8	135.3
100,000	20,200	9,163	800	243.8	881.4	268.6	460.7	140.4
200,000	40,400	18,325	800	243.8	998.5	304.3	475.6	145.0
500,000	101,000	45,813	800	243.8	1,177.6	358.9	492.2	150.0

Table XV. Impact of Changes on Mine, AP, M16A2

[Description: Mine, AP M16A2 with M605 Fuze, DODIC K092, Proposed NEW/QD = 1.33552 lb, U.S. IBD = 800 ft, HD 1.1 weight = 1.33552 lb, HD 1.3 weight = 0 lb]

No. of terms	QDW		Current U.S. IBD		Current NATO IBD		Proposed U.S. IBD	
	(lb)	(kg)	(ft)	(m)	(ft)	(m)	(ft)	(m)
1	1.33552	0.6058	800	243.8	886	270	656	200
5	6.6776	3.0289	800	243.8	886	270	656	200
10	13.36	6.06	800	243.8	886	270	656	200
20	26.71	12.12	800	243.8	886	270	656	200
50	66.78	30.29	800	243.8	886	270	656	200
100	134	60.58	800	243.8	886	270	656	200
200	267	121	800	243.8	886	270	656	200
500	668	303	800	243.8	886	270	791.4	241.5
1,000	1,336	606	800	243.8	886	270	914.3	279.0
1,500	2,003	909	800	243.8	886	270	986.5	301.0
2,000	2,671	1,212	800	243.8	886	270	1,037.8	316.6
3,000	4,007	1,817	800	243.8	886	270	1,110.2	338.8
5,000	6,678	3,029	800	243.8	886	270	1,201.8	366.7
10,000	13,355	6,058	800	243.8	975.5	297.3	1,326.6	404.8
20,000	26,710	12,116	800	243.8	1,105.1	336.8	1,451.9	443.0
50,000	66,776	30,289	800	243.8	1,303.3	397.2	1,618.5	493.8
100,000	133,552	60,578	800	243.8	1,476.4	450.0	1,745.1	532.4
200,000	266,104	121,156	800	243.8	1,672.6	509.8	1,872.3	571.2

Table XVI. Impact of Changes on 81-mm Mortar

[Description; Cartridge, 81-mm, HE, M374 without Fuze, DODIC C236, Proposed NEW/QD = 2.117 lb, U.S. IBD = 800 ft, HD 1.1 weight = 2.117 lb, HD 1.3 weight = 0.233 lb]

No. of terms	QDW		Current U.S. IBD		Current NATO IBD		Proposed U.S. IBD	
	(lb)	(kg)	(ft)	(m)	(ft)	(m)	(ft)	(m)
1	2.117	0.9603	800	243.8	886	270	656	200
5	10.585	4.8013	800	243.8	886	270	656	200
10	21.17	9.60	800	243.8	886	270	656	200
20	42.34	19.21	800	243.8	886	270	656	200
50	106	48.01	800	243.8	886	270	656	200
100	212	96.03	800	243.8	886	270	656	200
200	423	192	800	243.8	886	270	711.0	217.0
500	1,059	480	800	243.8	886	270	873.0	266.4
1,000	2,117	960	800	243.8	886	270	996.3	304.0
1,500	3,176	1,440	800	243.8	886	270	1,068.7	326.1
2,000	4,234	1,921	800	243.8	886	270	1,120.1	341.8
5,000	10,585	4,801	800	243.8	935.5	285.1	1,284.7	392.0
10,000	21,170	9,603	800	243.8	1,059.8	323.0	1,409.8	430.1
20,000	42,340	19,205	800	243.8	1,200.6	365.9	1,535.5	468.5
50,000	105,850	48,013	800	243.8	1,415.9	431.6	1,702.6	519.5
100,000	211,700	96,025	800	243.8	1,604.1	488.9	1,829.6	558.2
200,000	423,400	192,050	800	243.8	1,817.2	553.9	1,957.2	597.1
250,000	529,250	240,063	800	243.8	1,837.4	560.0	2,000.0	609.7

Table XVII. Impact of Changes on Cartridge, M1, 105-mm

[Description: Cartridge, 105-mm, M1, DODIC C445, Proposed NEW/QD = 4.90 lb, U.S. IBD = 1,200 ft, HD 1.1 weight = 5.08 lb, HD 1.3 weight = 2.87 lb]

No. of terms	QDW		Current U.S. IBD		Current NATO IBD		Proposed U.S. IBD	
	(lb)	(kg)	(ft)	(m)	(ft)	(m)	(ft)	(m)
1	4.9	2.2	1,200	365.7	886	270	656	200
5	24.5	11.1	1,200	365.7	886	270	656	200
10	49.0	22.2	1,200	365.7	886	270	656	200
20	98.0	44.5	1,200	365.7	886	270	656	200
50	245	111	1,200	365.7	886	270	656	200
100	490	222	1,200	365.7	886	270	736.7	224.8
200	980	445	1,200	365.7	886	270	859.4	262.2
500	2,450	1,111	1,200	365.7	886	270	1,022.3	311.9
1,000	4,900	2,223	1,200	365.7	886	270	1,146.3	349.8
1,500	7,350	3,334	1,200	365.7	886	270	1,219.1	372.0
2,000	9,800	4,445	1,200	365.7	922.6	281.2	1,270.8	387.7
5,000	24,500	11,113	1,200	365.7	1,088.0	331.6	1,463.3	438.2
10,000	49,000	22,226	1,200	365.7	1,232.6	375.7	1,562.1	476.6
20,000	98,000	44,452	1,200	365.7	1,396.4	425.6	1,688.5	515.2
50,000	245,000	111,130	1,200	365.7	1,646.8	501.9	1,856.5	566.4
70,000	343,000	155,581	1,200	365.7	1,749.6	533.3	1,918.4	585.3
100,000	490,000	222,259	1,200	365.7	1,837.4	560.0	1,984.2	605.4
150,000	735,000	333,389	1,200	365.7	1,837.4	560.0	2,000.0	628.2

Table XVIII. Impact of Changes on Guided Missile, AGM-88A (HARM)

[Description: G/M, AGM-88A, DODIC PB24, Proposed NEW/QD = 46.4144 lb, U.S. IBD 400 ft, HD 1.1 weight = 46.4144 lb, HD 1.3 weight = 327.414 lb]

No. of terms	QDW		Current U.S. IBD		Current NATO IBD		Proposed U.S. IBD	
	(lb)	(kg)	(ft)	(m)	(ft)	(m)	(ft)	(m)
1	46.4	21.1	400	121.9	886	270	656	200
2	92.8	42.1	400	121.9	886	270	656	200
5	232	105	400	121.9	886	270	656	200
7	325	147	400	121.9	886	270	656	200
10	464	211	400	121.9	886	270	656	200
15	696	316	400	121.9	886	270	798.8	243.7
20	928	421	400	121.9	886	270	849.7	259.3
50	2,321	1,053	400	121.9	886	270	1,012.7	309.0
70	3,249	1,474	400	121.9	886	270	1,072.7	327.3
100	4,641	2,105	400	121.9	886	270	1,136.6	346.8
150	6,962	3,158	400	121.9	886	270	1,209.3	369.0
200	9,282	4,210	400	121.9	913.6	278.5	1,261.0	384.8
500	23,205	10,526	400	121.9	1,077.5	328.4	1,426.4	435.2
700	32,487	14,736	400	121.9	1,144.7	348.9	1,487.4	453.8
1,000	46,410	21,051	400	121.9	1,220.6	372.0	1,552.2	473.6
1,500	69,615	31,577	400	121.9	1,313.1	400.2	1,626.1	496.1
2,000	92,820	42,102	400	121.9	1,382.8	421.5	1,678.6	512.1
5,000	232,050	105,256	400	121.9	1,630.8	497.0	2,000.0	563.4

Table XIX. Impact of Changes on Dispenser and Bomb, CBU-71A/B

[Description: Dispenser and Bomb, CBU-71 A/B, DODIC E828, Proposed NEW/QD = 148.0 lb, U.S. IBD = 400 ft, HD 1.1 weight = 148.0 lb, HD 1.3 weight = 0 lb]

No. of terms	QDW		Current U.S. IBD		Current NATO IBD		Proposed U.S. IBD	
	(lb)	(kg)	(ft)	(m)	(ft)	(m)	(ft)	(m)
1	148	67.1	400	121.9	886	270	1,250	381
2	296	134	400	121.9	886	270	1,250	381
5	740	336	400	121.9	886	270	1,250	381
7	1,036	470	400	121.9	886	270	1,250	381
10	1,480	671	400	121.9	886	270	1,250	381
20	2,960	1,343	400	121.9	886	270	1,250	381
50	7,400	3,357	400	121.9	886	270	1,250	381
70	10,360	4,699	400	121.9	931.9	284.0	1,280.8	390.4
100	14,800	6,713	400	121.9	993.7	302.9	1,345.1	410.0
200	29,600	13,426	400	121.9	1,125.7	343.1	1,470.5	448.2
500	74,000	33,566	400	121.9	1,327.6	404.6	1,637.2	499.0
700	103,600	46,992	400	121.9	1,410.5	429.9	1,698.7	517.7
1,000	148,000	67,131	400	121.9	1,504.0	458.4	1,763.9	537.6
1,500	222,000	100,697	400	121.9	1,617.9	493.1	1,838.3	560.3
2,000	296,000	134,263	400	121.9	1,703.8	519.3	1,891.2	576.4
3,000	444,000	201,394	400	121.9	1,832.8	558.6	1,966.0	599.2

CHAPTER 5. SUMMARY

Sufficient data have now been developed by the HD 1.2 trials program to indicate a probable course for suggested rule changes. These changes will take a form quite similar to that currently used by NATO and the U.K., namely, that the IBD depends on the explosive weight raised to some power or powers with both a minimum and maximum range. Further, the definition of energetic material weight to be used in these calculations is nearly identical with that currently used in NATO/U.K. i.e., only the explosive weight of the HD 1.1 material is counted.

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US ARMY MATERIEL COMMAND
ATTN AMCAM-PP
5001 EISENHOWER AVENUE
ALEXANDRIA VA 22333-0001 1

COMMANDER
US ARMY MATERIEL COMMAND
ATTN AMCSF
5001 EISENHOWER AVENUE
ALEXANDRIA VA 22333-0001 1

COMMANDER
US ARMY MATERIEL COMMAND
ATTN AMCSF-E
5001 EISENHOWER AVENUE
ALEXANDRIA VA 22333-0001 1

COMMANDER
US ARMY MATERIEL COMMAND
ATTN AMCSF-X
5001 EISENHOWER AVENUE
ALEXANDRIA VA 22333-0001 1

COMMANDER
US ARMY MATERIEL COMMAND
ATTN AMXED
5001 EISENHOWER AVENUE
ALEXANDRIA VA 22333-0001 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-AE
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-AEE
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-AEE-BR
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-AEP
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-AES
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-AL
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-ALI
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-AEP
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
ARMAMENT RSRCH DEV & ENG CTR
US ARMY ARM MUNITIONS & CHEM COM
ATTN AMSTA-AR-QAS
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
US ARMY SAFETY CENTER
ATTN CSSC-Z
FT RUCKER AL 36362-5363 1

COMMANDER
US ARMY SAFETY CENTER
ATTN CSSC-IPR
FT RUCKER AL 36362-5363 1

COMMANDER
US ARMY SAFETY CENTER
ATTN CSSC-IS
FT RUCKER AL 36362-5363 1

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US ARMY SAFETY CENTER
ATTN CSSC-PP
FT RUCKER AL 36362-5363 1

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ATTN LIBRARY
NATICK MA 01782 1

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ATTN SIOAC-DEV
SAVANNA IL 61074-9639 1

DIRECTOR
US ARMY DEFENSE AMMUNITION CENTER
ATTN SIOAC-ASC
SAVANNA IL 61074-9639 1

DIRECTOR
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SAVANNA IL 61074-9639 1

DIRECTOR
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ATTN SIOAC-ESL
SAVANNA IL 61074-9639 1

DIRECTOR
US ARMY TECH CNTR FOR EXPLO SAFETY
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SAVANNA IL 61074-9639 1

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ATTN DRXTH-TE
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CHAMPAIGN IL 61820 1

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ATTN CEWES-SE (DAVIS)
3909 HALLS FERRY ROAD
VICKSBURG MS 39180-6199 1

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HUNTSVILLE AL 35807-3801 1

COMMANDER
US ARMY MISSILE COMMAND
ATTN AMSMI-SF
REDSTONE ARSENAL AL 35898-5130 1

COMMANDER
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ATTN STERT-TE-F-FL
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US ARMY TEST AND EVAL COM
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APG MD 21005-5055 1

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US ARMY RESEARCH LABORATORY
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US ARMY RESEARCH LABORATORY
ATTN AMSRL-WT-TB (STARKENBERG))
APG MD 21005-5066 1

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HUNTSVILLE AL 35807-4301 1

COMMANDER
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ATTN CEHNC-ED-CS-S (ZEHRT)
PO BOX 1600
HUNTSVILLE AL 35807-4301 1

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US ARMY ENGR SUPT CNTR HUNTSVILLE
ATTN CEHNC-ED-CS-S (FARSOUN)
PO BOX 1600
HUNTSVILLE AL 35807-4301 1

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PO BOX 1600
HUNTSVILLE AL 35807-4301 1

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WRIGHT PATTERSON AFB OH 45433-5001 1

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KIRTLAND AFB NM 87117-5671 1

AIR FORCE SAFETY CENTER
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9700 AVENUE G SE
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EGLIN AFB FL 32542-6879 1

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COCHRANS MILL ROAD
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WASHINGTON DC 20590 1

DEPARTMENT OF TRANSPORTATION
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400 7TH STREET SW
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HUNTSVILLE AL 35815-1506 1

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614 MOUNTAIN GAP DRIVE SE
HUNTSVILLE AL 35803 1

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PO BOX 6477
SAN ANTONIO TX 78209 1

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ARLINGTON VA 22202 1

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6220 CULEBRA ROAD
SAN ANTONIO TX 78228-0510 1

SOUTHWEST RESEARCH INSTITUTE
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PO BOX 28510
6220 CULEBRA ROAD
SAN ANTONIO TX 78228-0510 1

SOUTHWEST RESEARCH INSTITUTE
ATTN TECHNICAL LIBRARY
PO BOX 28510
6220 CULEBRA ROAD
SAN ANTONIO TX 78228-0510 1

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10 WEST 35TH STREET
CHICAGO IL 60616 1

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SOCORRO NM 87801 1

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ATTN P A PERSSON
SOCORRO NM 87801 1

EMRTC
NEW MEXICO INST OF MINING & TECH
ATTN D COLLIS
SOCORRO NM 87801 1

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HC 3 BOX 458
LUTSEN MN 55612-9705 1

JHU/CPIA
ATTN SECURITY OFFICER
10630 LITTLE PATUXENT PKWY STE 202
COLUMBIA MD 21044-3200 1

ATLANTIC RESEARCH CORPORATION
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5945 WELLINGTON ROAD
GAINESVILLE VA 22055-1699 1

AEROJET SOLID PROPULSION
PO BOX 15699C
SACRAMENTO CA 95852-1699 1

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7 BUCKINGHAM WAY
SHALIMAR FL 32579 1

VICTOR TECHNOLOGY
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1537 FOURTH STREET SUITE 218
SAN RAFAEL CA 94901 1

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5941 S MIDDLEFIELD ROAD STE 100
LITTLETON CO 80123 1

BAKHTAR ASSOCIATES
2429 WEST COAST HIGHWAY SUITE 201
NEWPORT BEACH CA 92663 1

BOOZ-ALLEN & HAMILTON INC
5186 POTOMAC DRIVE
ATTN W SMITH
PO BOX 218
DAHLGREN VA 22448 1

COMMANDER
NAVFAC ENGINEERING SERVICES CENTER
ATTN ESC62 (MALVOR)
1100 23RD AVE
PORT HUENEME CA 93043-4370 1

Internal

PM5	1
102	1
041	1
041B	1
044D	1
044F	1
840L	3
8430	1
9	1
920	1
950	1
950T	10
9530G	1